SD11
A5A38
21

R. E. Francis

TECHNICAL
PAPER
NUMBER 21

FIRE-WEATHER SURVEY CAN AID PRESCRIBED BURNING

M. J. SCHROEDER
C. M. COUNTRYMAN

CALIFORNIA
FOREST AND RANGE
EXPERIMENT STATION
KEITH ARNOLD, DIRECTOR
BERKELEY - NOVEMBER 1957

FOREST SERVICE - U. S. DEPARTMENT OF AGRICULTURE

FIRE-WEATHER SURVEY CAN AID PRESCRIBED BURNING

By Mark J. Schroeder, Meteorologist, U. S. Weather Bureau
and Clive M. Countryman, Forester

Division of Forest Fire Research

Technical Paper No. 21 November 11, 1957

CALIFORNIA FOREST AND RANGE EXPERIMENT STATION
FOREST SERVICE, U.S. DEPARTMENT OF AGRICULTURE

The Experiment Station is maintained at Berkeley, California in cooperation with the University of California.

Agriculture--Forest Service, Berkeley, Calif.

FIRE-WEATHER SURVEY CAN AID PRESCRIBED BURNING

By Mark J. Schroeder, Meteorologist, U. S. Weather Bureau
and Clive M. Countryman, Forester

Division of Forest Fire Research

Foresters, particularly those concerned with type conversion, are using fire more and more each year as a tool to clear California brushland. Fire technicians are making this tool more efficient. They have developed area-ignition firing techniques to extend the range of fuel conditions under which safe and effective burns can be made. They have devised electrical firing systems that permit large areas of brush to be burned in a half hour or less. But how will the fire burn?

This question must be answered before a burn can be attempted. It points up the need for reliable information about local burning conditions. Weather, vegetation, and topography differ widely from area to area. Fires seldom burn in the same way. Knowledge of the detailed weather patterns is essential if the fire is to be set under conditions such that it will do the job and still not get away. Wind conditions are especially important. Area ignition requires low wind speeds, and even though electrical firing systems permit area ignition during relatively short periods of low wind speed, the fire boss must know when these lulls will occur. Established fire-weather stations and Weather Bureau climatological stations seldom provide weather data in enough detail and continuity.

A short-term survey of fire-weather, we reasoned, might supply the needed information. Summer weather conditions over much of California remain relatively unchanged for long periods of time. Furthermore, the same conditions tend to recur in a general way each year. A survey conducted for a few days before a scheduled burn seemed to promise a quick means of determining the most probable fire-weather pattern for the burn area.

A prescribed burn scheduled for August 29, 1956, at Iron Mountain, Magalia Ranger District of the Lassen National Forest, gave us the chance to test this hypothesis. Through cooperative efforts of the Lassen National Forest, the California Forest and Range Experiment Station, and the U. S. Weather Bureau, a fire-weather survey was organized and conducted in the proposed burn area.

Specifically, the objectives of the survey were to:

1. Provide the fire boss with a complete picture of the diurnal march of temperature, relative humidity, and wind over the fire site.

2. Explore the possibility of adapting this type of fire-weather survey method to use on going wildfires.

3. Develop sampling methods and instrumentation.

4. Measure the effect of fire on local winds.

The Area

The burn area is at the head of Beaver Creek drainage on the west slope of the Sierra Nevada, about 26 miles north and 7 miles east of Chico, California. The area of 1,000 acres varies in elevation from about 2,800 feet to 3,800 feet. Beaver Creek branches at the south end of the area, and the two branches extend nearly parallel northward; a long ridge separates the two. The rim of the drainage has a number of saddles, the lowest of which is about 3,150 feet on the east side. Beaver Creek valley opens into Deer Creek canyon about a mile and a half below the burn area. Deer Creek canyon in turn runs west-southwest from there and opens into the Sacramento Valley about 20 miles north of Chico.

Sampling Methods and Instrumentation

Over much of the west slope of the Sierra Nevada a west to southwest wind is common during the day, and east to northeast down-slope drainage winds during the night. Study of records of fire-weather stations near the area showed that this wind condition could be expected in late August for the general area. The records also indicated that temperatures in the mid-80's and relative humidities of 20 to 25 percent were likely.

From a topographic map we selected 10 places where weather measurements would be desirable. Five days before the scheduled burn, we went over the ground and asked the district ranger for his suggestions. He picked 3 spots where he felt wind information was desirable for fire-control purposes. They coincided with 3 of the 10 locations selected on the topographic map. One was at the bottom of the canyon (A, fig. 1), another on the large saddle on the east side of the drainage (C, fig. 1), and the third on a saddle on the northwest rim of the drainage (D, fig. 1).

We installed an anemometer and a wind vane at each of these places. Only 5 sets were available. The two most useful of the remaining sites, we decided, were near the top of the ridge on the south side of the drainage (B, fig. 1) and on the middle ridge near the center of the area (E, fig. 1).

Wind speed was measured with a Friez 3-cup totalizing anemometer, and wind direction with a nonrecording wind vane. The anemometer and wind vane were mounted on a cross arm atop a large aluminum tripod with adjustable legs (fig. 2). Adjustable legs permitted the instruments to be set up quickly on uneven ground. The instruments were mounted 10 feet above ground level. Electrically operated counters were used to register the 1/10-mile contacts made by the anemometer. A 6-volt dry battery supplied the power.

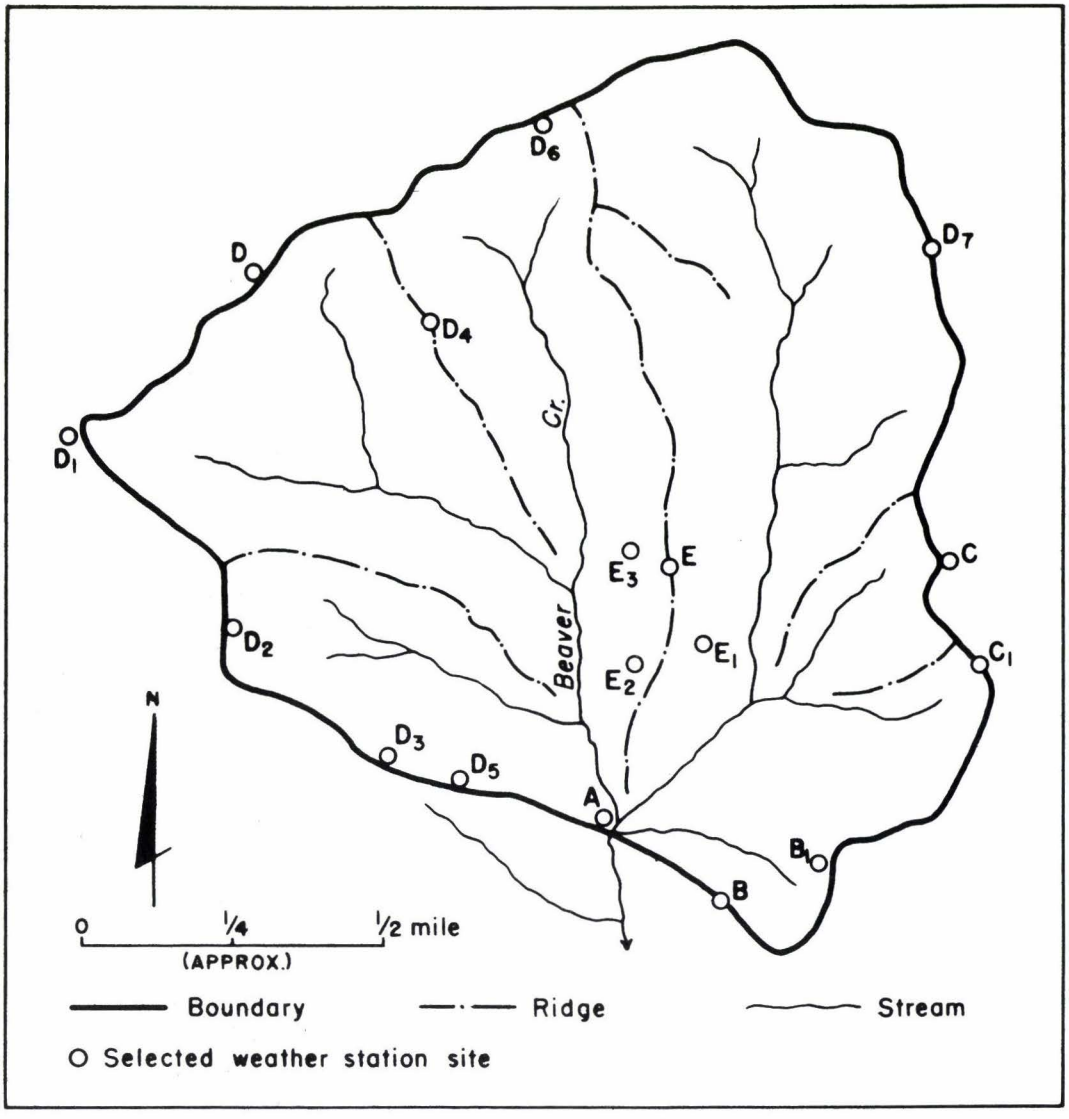

Figure 1.--Station locations, Iron Mountain fire-weather survey. Letters with subscripts indicate where supplementary observations were made with portable instruments.

Since the instruments were nonrecording, it was necessary to read them manually. A 10- to 20-minute sample of wind speed was taken each hour at each of the 5 stations, and as many spot samples of wind direction were taken at 5-minute intervals as was possible with the available manpower. Temperature and relative humidity were measured with sling psychrometers at stations B, C, D, and E. We continued the observations from about 0800 to 1800 or 1830 PST each day for 3 days before the fire and on the day of the fire.

Figure 2.--Wind vane and anemometer installation at station C.

Wind observations were also taken with portable wind-speed indicators at several other points (fig. 1) to obtain a more complete picture. Visual observations of eddies were also noted.

At station B an instrument shelter was installed containing maximum and minimum thermometers and a hygrothermograph. Also at that station a set of 1/2-inch fuel moisture sticks was exposed and measurements taken several times each day (fig. 3).

Analysis of Data

All observations for August 26, 27, and 28 were tabulated during the evening of August 28, the day before the burn. Wind directions and speeds were plotted on small maps of the area. The maps were drawn at about 3-hour intervals for August 26 and 27, and hourly for August 28.

As fate would have it, this 3-day period was one of changing general weather conditions, and the wind pattern was different each day. On the morning of August 26, three days before the burn, the wind flow was southwesterly in the canyon bottom, and southwest to west at higher locations. By afternoon the wind flow became northerly (down canyon) at the canyon bottom and west to northwest at higher

locations (fig. 4). The strongest winds were recorded in the early morning hours. No observations were taken during the night. Next morning the winds were still northerly in the canyon bottom, but at higher locations they had set in from an easterly or east-northeasterly direction. A weak surface cold front passed through the area in the early afternoon of August 27. The wind at higher locations then set in from the west and northwest, but in the canyon bottom it remained northerly (fig. 5). The highest wind speeds were recorded at the first observations in the morning, though another peak was noted around mid-afternoon.

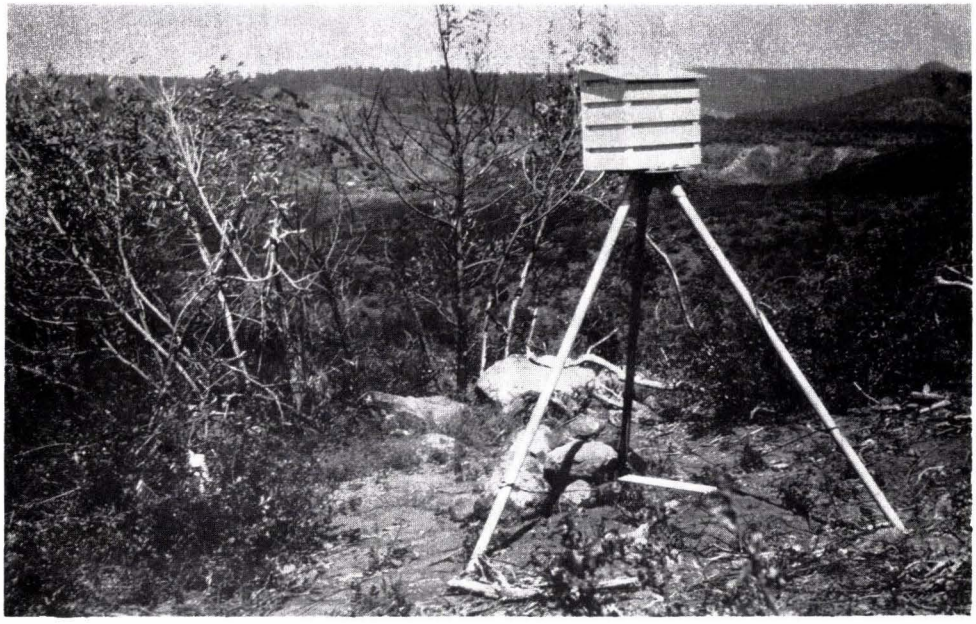

Figure 3.--Instrument shelter and fuel moisture sticks at station B. The burn area is in the background.

Early forenoon of August 28 the easterly downslope winds ceased and daytime west to southwest upslope winds began at the higher locations. The wind flow at the canyon bottom was already up-canyon at the time of our earliest observations. The wind pattern remained essentially the same all day (fig. 6). The wind speeds increased until mid-afternoon and then decreased.

Observations with portable instruments showed the presence of roll eddies on the lee side of ridges within the burn area. They also showed that winds in the canyon bottoms and on lower slopes were generally up-slope in direction and of low speed.

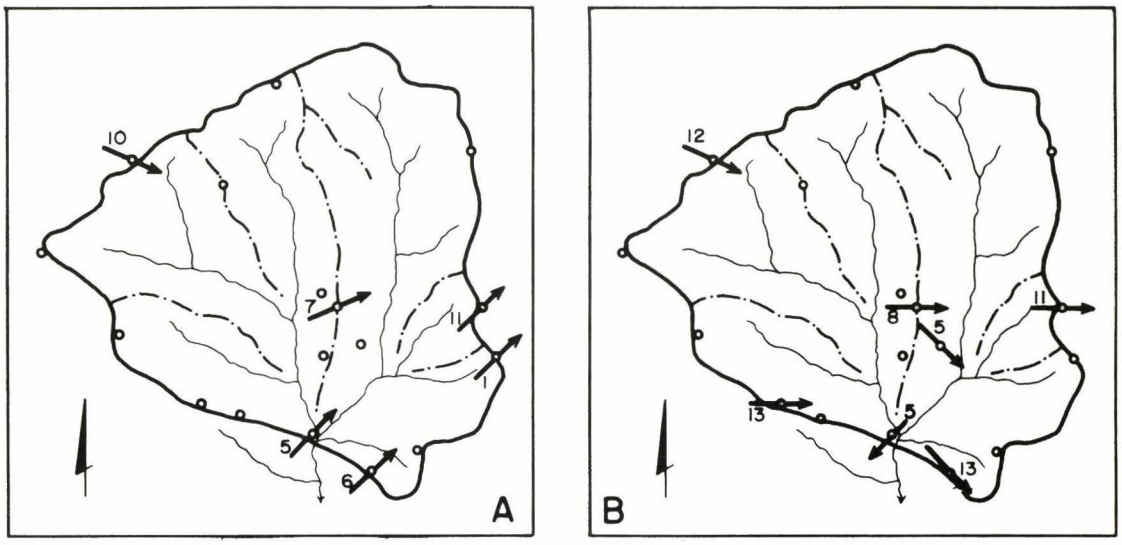

Figure 4.--Observed winds Sunday, August 26, 1956. A, 1100-1200 PST. B, 1500-1600 PST.

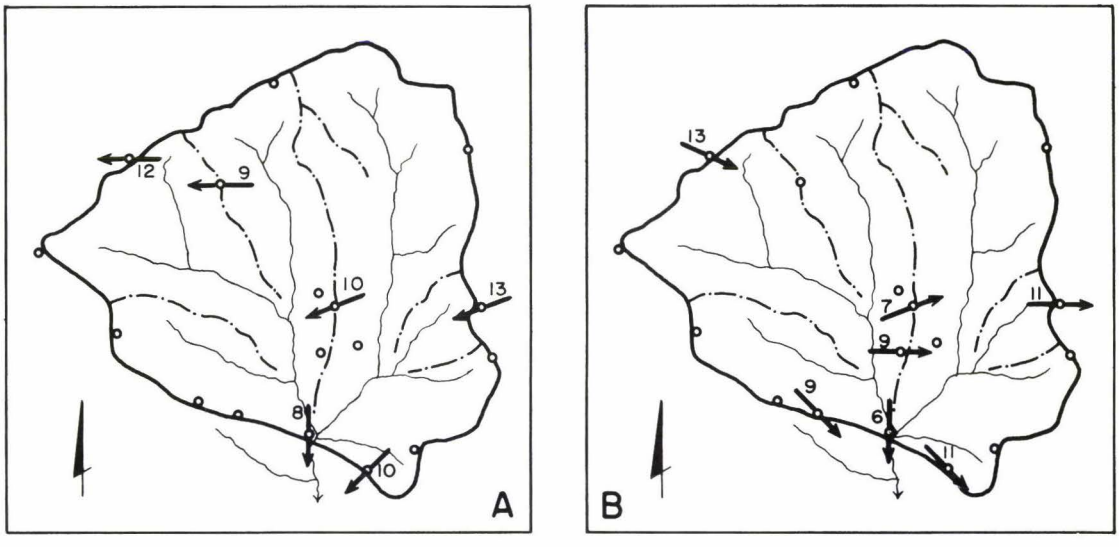

Figure 5.--Observed winds Monday, August 27, 1956. A, 0900-1000 PST. B, 1400-1500 PST.

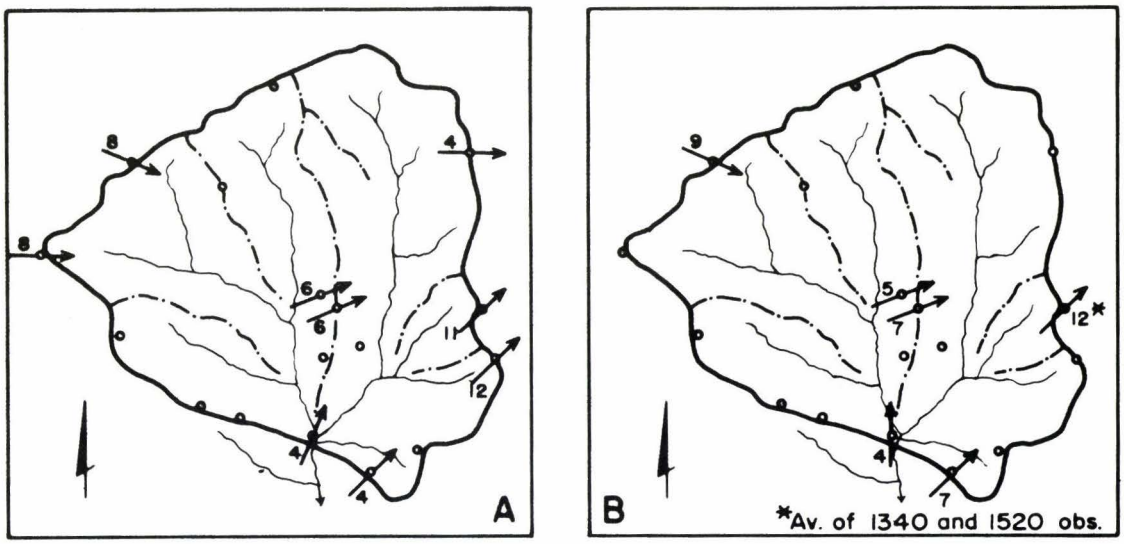

Figure 6.--Observed winds Tuesday, August 28, 1956. A, 1000-1100 PST. B, 1400-1500 PST.

Wind patterns in the burn area reflected the general weather pattern and the air flow aloft as shown on the surface and upper-air weather maps.[1/] From the afternoon of August 26 through most of August 27, when surface winds in the burn area tended to blow from the north, the winds aloft were rather strong northerly over northern California. This pattern was the result of a low pressure center aloft which had moved from the Puget Sound area to western Montana, while high pressure aloft remained along the coast. The northerly winds aloft over northern California had decreased by the evening of August 27 and remained rather light the next day.

We determined from the weather maps that the local wind pattern on Tuesday, August 28, was probably the usual summertime pattern for the area.

Weather Forecast and Results

The general weather data available indicated that a low pressure center would develop aloft over southern California, making showers likely in the central and southern Sierra Nevada mountains. We did not expect this development to influence the weather or surface wind flow in the burn area.

We noted indications August 28 that a greater inflow of marine air into the central Sacramento Valley would occur the following day. Logically this would mean higher wind speeds, lower afternoon temperatures, and higher afternoon relative humidities in the burn area.

1/ Made available by the U. S. Weather Bureau Fire-weather Forecaster from Redding who helped in the survey and assisted in preparing the forecast.

Consequently, the weather forecast we made that night for mid-afternoon of August 29 called for lower than normal temperatures (78° to 83° maximum), higher than normal humidity (20-25 percent minimum), and a windflow pattern similar to August 28 but with somewhat higher speeds. Predicted winds for the burn area were plotted on a small map (fig. 7) for use by the fire boss.

Weather observations made the morning of the burn, and synoptic reports received by radio tended to substantiate the forecast made the night before. The readings did indicate that the humidities would not be as low as forecast, but the probable difference was not great enough to issue a revised forecast.

The actual winds measured in the burn area shortly before the scheduled burn were plotted on a map (fig. 8). The expected increase in wind speeds did not materialize. The wind speeds turned out to be about the same as on the day before. The forecast directions were correct, however. The marine air did spread into the central valley and even into the burn area. Humidities were even higher than had been forecast. The lowest humidity was 27 percent, but some stations had no readings lower than 33 percent that afternoon.

Effects of Fire on Wind Pattern

To measure the effect of the fire on local winds, we continued observations during the fire at three of the station sites (A, B, and C, fig.1), at two locations on the western ridge, and at one location on the southwest side of the fire area.

At station A in the canyon bottom, the wind speed increased from 3.5 miles per hour to 5 miles per hour shortly after the fire was touched off. Wind speed also increased slightly at the two observation points on the west side ridge. The fire had no noticeable effect at station B or at the observation point on the southwest side of the fire.

The effect of the fire was pronounced at station C, the low saddle on the east rim. Here the wind was 11 miles per hour from the west-southwest when the fire was ignited at 1610 PST. As the fire developed, the wind became variable in both speed and direction. We observed east winds at 1629 and 1634. The main fire was centered on the middle ridge and in the canyons on either side. At about 1640 it merged into one column almost due west of station C and effectively blocked any flow of westerly wind through the saddle. During the next half hour the wind continued to vary a great deal, blowing mostly from east around through south and southwest. At one time, 1659 PST, a southeast wind of 7 m.p.h. was observed. At 1715 the convection column split, and observers at station C could see the western rim between the two columns. By then the wind at the saddle returned to a southwest to west-southwest direction.

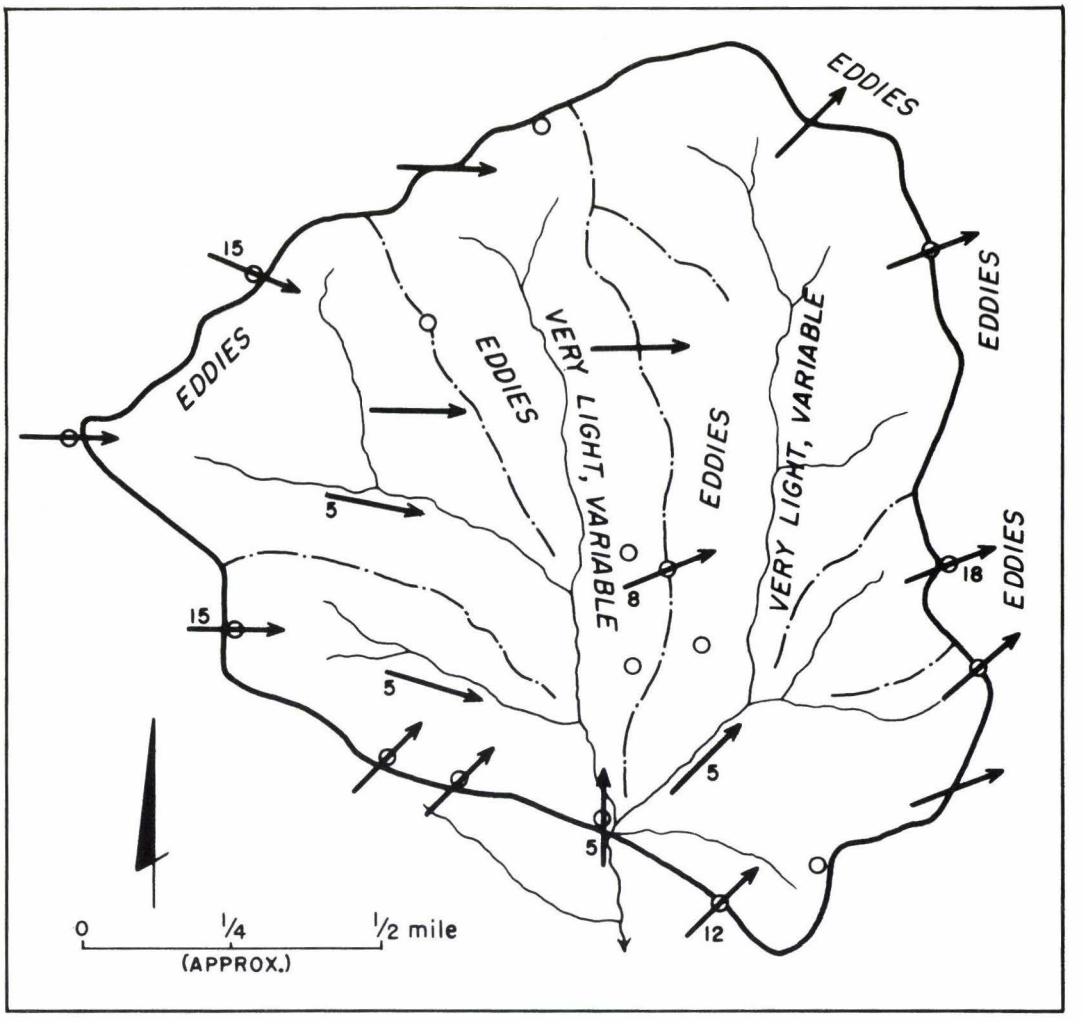

Figure 7.--Forecast winds for afternoon of Wednesday, August 29, 1956.

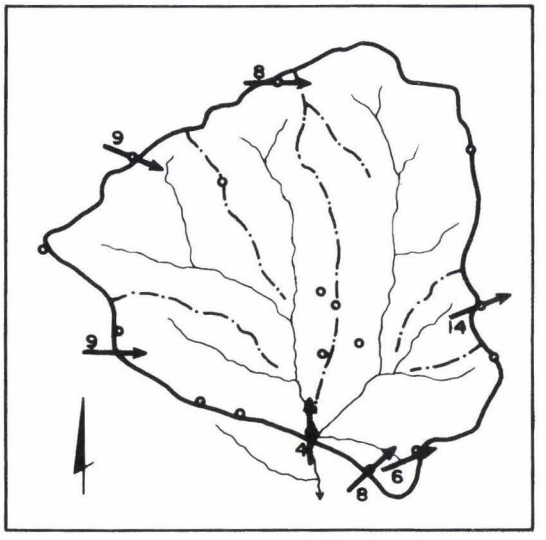

Figure 8.--Observed winds for Wednesday, August 29, 1956, 1400-1500 PST.

The relatively great influence of the fire on the winds at station C leads to an interesting hypothesis which, if true, would explain some peculiarities of fire behavior. This station is some 200 feet higher than the canyon bottom directly to the west and 350 feet higher than station A. The relatively small effect on the wind at station A indicates the lack of a strong indraft into the base of the fire. This was confirmed by men firing some distance down from the rim of the canyon. The observations, therefore, suggest that the entrainment of air into the side of the convection column was considerably greater than the indraft into the base of the fire. It is possible that the topography influenced the effect in this case.

Conclusions

1. Fire-weather surveys, and particularly wind studies, may be misleading unless the interaction between the fire itself and pertinent weather elements is considered.

2. It appears possible for an experienced team of observers to move into an area with weather instruments and in a relatively few days (at least in the interior of California during the summer season) determine local fire-weather patterns, relate them to synoptic weather patterns, and provide other weather information that will greatly assist the fire-weather forecaster in preparing detailed forecasts for the area.

3. Fire-weather surveys such as this can add considerably to our knowledge of local fire-weather patterns and the effect of fire on them. They also may provide information which will allow more accurate prediction of fire behavior.

4. Lightweight weather instruments and supports designed specifically for this type of survey are needed.

5. Some instruments are needed to record weather data continuously at selected key points. Then observers with portable instruments could explore fire-weather patterns in more detail.